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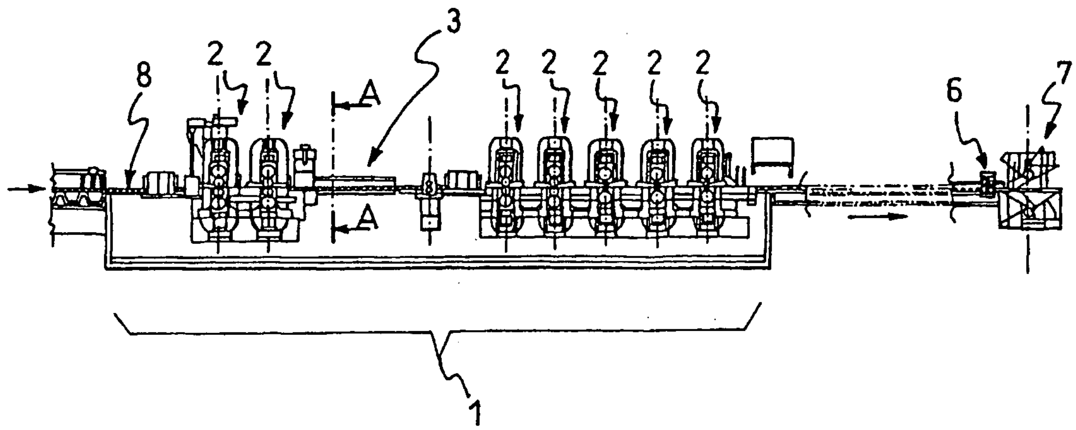

(57) Abstract

The invention relates to a rolling mill for hot-working thin steel strips and other similar metallic materials; in particular, this rolling mill consists of a series of tandem arranged stands (2) which act simultaneously on a strip and among which there is at least one cooling device (3). The latter is designed to lower the temperature of the strip in a controlled manner so as to change the metallurgical phase of the associated rolled material in the space between one stand and the other. According to a preferred embodiment of the invention, the rolling mill is of the finishing type and the cooling device makes use of water with laminar–flow pipes.

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HOT-ROLLING MILL FOR THIN STRIPS

The invention relates to the hot rolling of flat products and in particular thin or ultra-thin products (also said UTHS: Ultra Thin Hot Strips), i.e. ribbons or strips with thicknesses of less than 1.5 mm made of steel or other similar metallic materials.

In recent times, for manufacturing rolled products with such thicknesses, the hot-working process is being increasingly used as an alternative to the traditional cold-working process: with said process, indeed, it is possible to reduce the number of operating steps needed to obtain the final product, thus giving rise to an advantageous reduction in the production costs.

For more details concerning this development in the field and the underlying technical advantages, reference should be made to the scientific publications dealing with the subject.

Here, however, attention is drawn to the fact that in order to obtain hot-rolled thin strips which have properties, including metallurgical properties, similar to those of cold-rolled strips, without the need for further treatment apart from pickling or a slight surface finishing (also referred to as "skin-passing"), it is necessary to work under operative conditions which are able to produce changes in the crystalline structure of the material.

For example in the case of steel the temperatures along the finishing rolling mill, i.e. the rolling mill from where the final strip comes out for being then cut and wound onto reels, may be those which produce a transition from the austenitic range to the ferritic range.

The presence of these transitions represents an important variable which must be controlled because it may condition the entire production process.

Indeed, if the abovementioned transition from the austenitic phase to the ferritic phase occurs in an uncontrolled manner, for example owing to a sudden change in the working conditions (temperature of the strip or the like), it may happen that the zone of the rolling mill where it occurs moves, with time, between one inter-

stand (this is the name of the space between two adjacent rolling stands) and the next one or, which is much more demaging, that it is located in connection with the working rolls of a stand.

These events cause sudden changes of the rolling forces, which alter both the geometry of the strip (in particular the flatness) to the detriment of its final quality, and the operating conditions which thus result difficult to control thereby increasing the risk of stickings with all the negative consequences that may be easily imagined. Moreover, in the case where the transition occurs within a stand, the metallurgy of the strip is also altered and non-uniform.

At present, in order to avoid risks, it is established practice to roll the strips keeping them at temperatures higher than the abovementioned transition temperature, and to cool them at the outlet of the finishing rolling mill; this requires the use of suitable means to keep the strip at the desired temperature, such as heating panels between the rough-shaping mill and the finishing mill, tunnel furnaces and the like, which lengthen the rolling plant and slow down production.

Furthermore, this type of rolling process is fairly wasteful either because it requires the use of the temperature-maintaining means already referred to, either because a greater final cooling of the strip is required in any case to reduce the temperatures thereof.

To sum up shortly, it may be stated that it would be desirable to have a rolling process wherein the strip is worked while it cools gradually, moving through the various stands, until it reaches a final temperature useful to obtain the desired metallurgical structure.

The present invention aims at achieving this result; i.e. it has the object of providing a hot-rolling mill intended in particular, but not exclusively, for working thin strips, which is able to operate also in the case of transitions of the rolled material that create changes in the working conditions, as described above.

This object is achieved by a rolling mill whose characterising features are set out in the claims which will follow.

These features and the effects arising therefrom will emerge more clearly from the description hereunder, concerning a non-limiting example of rolling mill according to the invention, shown in the accompanying drawings wherein:

- Fig. 1 shows a side view of the end section of a rolling plant according to the invention;

- Figs. 2 and 3 show a view along the cross-section A-A of Fig. 1, of the abovementioned plant section in respective operating conditions;

- Fig. 4 shows a diagram illustrating the evolution of the temperatures as a function of the space in the plant section according to the preceding figures;

- Figures 5 and 6 show respective side views along the lines V-V and VI-VI of Fig. 2.

With reference to the abovementioned drawings, numeral 1 denotes a finishing rolling mill consisting of a series of stands 2 which, in a tandem arrangement, roll a strip N supplied from a plant for casting thin blooms.

The rolling stands 2 are of the type with opposing rolls and, being already known per se, they are therefore not described in greater detail below; as regards their tandem arrangement, on the other hand, this must be understood as being an arrangement where, during rolling, the stands operate at the same time on a same strip thereby being separate from this point of view, from any rough-shaping mill or other series of rolling stands arranged upstream of the finishing rolling mill.

A cooling device 3 with laminar-flow pipes and a heater 4 for intermediate heating, described in greater detail below, are also present between the second and the third stand of the finishing rolling mill 1.

As generally occurs in these types of plant, downstream the rolling mill 1 there are also preferably provided a shearing device 6 for cutting the strip N into shorter portions and a reel 7 for winding these portions, in accordance with what is known in the art.

Furthermore it must be pointed out that the strip N is supported during its advancing movement, i.e. upstream and downstream of the rolling mill 1 as well as

along it, by a roller conveyer 8 and by guides 9 of the type commonly used in the art.

Turning now to consider the cooling device 3, it is of the type consisting of pipes 30a, 30b with laminar flow, already known per se; as can be seen in Figures 2 and 3, a plurality of these pipes is arranged above and below the strip N, lying side by side so as to spray the cooling liquid toward the strip with laminar parallel jets. It should be noted that the bottom pipes 30b are located at a smaller distance from the strip N than the upper pipes 30a because, since the liquid must be sprayed upwards, the length of the jet must be short in order to keep it in laminar-flow conditions (Fig. 6 shows in broken lines the shape of two rolls of different stands, between which the pipes 30b are located).

The pipes 30a, 30b are supplied with water from a storage tank 31 which is raised in order to maintain a regular hydraulic head and to which they are connected via a duct 32 and respective manifolds 33, 34.

The cooling device 3 with laminar-flow pipes has the capacity of providing a controlled refrigerating action; namely it is able to remove a predefined quantity of heat from the strip, depending on the various operating parameters of the rolling process (such as the speed of the advancing movement and the temperature of the strip, the time required for cooling, etc.).

Consequently, the device 3 is provided with an adequate regulating system, suitable for operation of the pumps, valves and any other equipment required, in order to obtain the cooling of the strip N for fulfilling the requirements of the rolling process.

In accordance with a preferred embodiment of the invention, the cooling device 3 operates in the same zone of a fast-action heater 4.

As can be noted from Figures 2 and 3, this heater is mounted on a hinged system consisting of a pair of cranks 40, 41 operated by a hydraulic arm 42 so as to be positioned above the strip N, between the pipes 30a and 30b of the cooling device 3. In order to allow the displacement of the heater 4, the upper pipes 30a may also be raised by means of a hydraulic cylinder 35.

This makes it possible to limit the distance of the two stands between which the device 3 and the heater 4 are located, thereby avoiding to lengthen further the rolling mill.

The operating principle of the finishing rolling mill 1 and the other elements considered above, is described below in connection with the working of an ULC (Ultra Low Carbon) steel.

The strip N produced by the continuous casting of thin blooms reaches the entrance of the finishing rolling mill 1 at a temperature where it is in the austenitic range, namely about 1100 °C; in these conditions it is rolled by the first two stands where it goes through the respective cooling phases R1 and R2, as indicated in Figure 4.

Upon leaving the second stand, the strip is cooled by the device 3; the lowering of temperature resulting therefrom is such as to bring the strip into the ferritic range.

More particularly, the phase transition takes place in the space between the second and the third stand following a predetermined line depending on the abovementioned operating parameters which are detected upon entry of the strip N into the rolling mill 1; advantageously, by choosing a temperature close to 800 °C, it is also possible to produce a so-called "isothermal" rolling phase.

In this condition, indeed, the deformation which the strip undergoes in the subsequent rolling stands generates heat (as shown by the temperature rise F1, F2, F3, F4, F5 detected at each stand), so as to substantially compensate for the cooling of the strip by means of irradiation and conduction with the working rolls.

At the end of the finishing rolling mill 1, the strip N is allowed to cool so as to allow release of the stresses in a manner similar to what happens in an annealing treatment.

After this, the strip is cut by the shears 6 and then finally wound onto the reel 7; it should only be pointed out that all the operations referred to above occur in rapid succession because the strip emerging from the finishing rolling mill advances at

fairly high speeds of the order of 20 m/s.

As can be seen from this example, the use of a cooling system in accordance with the invention allows the rolling to be performed in the austenitic and ferritic range along a same rolling mill, in this case the finishing rolling mill formed by the stands which act in tandem on the strip.

This result is made possible by the device with laminar-flow pipes which is able to vary the temperature in a controlled manner, ensuring at the same time that the transition from the austenitic range to the ferritic range takes place entirely within a single inter-stand.

In other words, in order to obtain the results of the invention it is necessary that the cooling system arranged along the rolling mill, provides a controlled action over a wide temperature range; in the example considered, the cooling range between the second and the third stand is equivalent to about 200 °C.

The graph shown in Fig. 4 refers to a strip with a thickness of 12 mm in the cooling zone; the cooling over 200 °C is in this case made necessary also by the subsequent isothermal rolling process.

It is also necessary to emphasise the great efficiency of the device with laminar-flow pipes which allows the temperature of the strip to be lowered over intervals of 200 °C, even within spaces of only 4-6 metres length. This fact, in addition to constituting an advantage from the overall dimensions point of view, also avoids to provide additional means for adjusting the tension (so-called "pull") of the strip between one stand and the other.

More generally, it may be stated that the reduction in temperature of the strip must in any case allow a wide margin of safety in order to compensate for any variations of the operating conditions which may occur during rolling.

The cooling devices with laminar-flow pipes are able to satisfy all these conditions: indeed they have high heat-exchange properties and a considerable capacity to regulate the heat removed, which may vary between a maximum and a minimum, in terms of ratio, of 8 to 1.

Similar results are obtained by means of regulation of the liquid flow performed by adjusting the delivery pressure and the compact arrangement of the pipes which, further to limiting the overall dimensions of the device, allow also a greater flow of heat per unit of length to be removed.

It should also be pointed out that, in the example described above, the finishing rolling mill 1 is made operationally flexible by the use of the intermediate heater 4.

Indeed, the presence of the cooling device 3 lengthens somewhat the distance between the second and the third rolling stand; therefore, should it be required to perform rolling solely in the austenitic range, namely without forced cooling of the strip and therefore without delivery of water to the device 3, uncontrolled cooling of the strip between the two aforementioned stands would inevitably occur.

The temperature of the strip would consequently drop, with the risk of having conditions of transition from the austenitic range to the ferritic range which would give rise to the drawbacks already mentioned at the beginning.

The intermediate heater 4, however, remedies this situation by providing the heat necessary to avoid cooling of the strip; in other words, it has the function of compensating for the heat losses and keeping constant the temperature of the strip between the two stands concerned.

For this reason, gas ovens and in particular those with direct-flame burners, which nowadays are commercially available, are preferred; indeed they are able to ensure effective heating and are operationally flexible, making them suitable for satisfying the various operating conditions which may arise in practice.

Obviously variations of the invention with respect to the example described above are also possible.

At first it should be pointed out that the position along the rolling mill of the cooling devices, may differ from case to case; for example these devices may be located between the first and the second stands or between the third and the fourth one and so on, i.e. not only between the second and third stands as in the example

above. These variations will be influenced by the type of working process envisaged for the rolling mill (i.e. whether it is a rough-shaping or finishing mill), the temperature and the dimensions of the strip, the material to be rolled and other factors.

Furthermore it is also possible to envisage the use of several cooling devices in a same rolling mill; i.e. there may be rolling mills with cooling devices also arranged between the first and second stands, between the third and fourth one, between the fourth and fifth, etc.

These and other variations, however, fall within the scope defined by the claims which follow.

CLAIMS

1. Rolling mill for hot-working metal strips and the like, comprising a plurality of tandem arranged rolling stands (2) that operate together on a strip to be rolled (N), characterized in that between at least two of these stands there is provided a cooling device (3) designed to lower the temperature of the strip in a controlled manner so as to cause a change in the metallurgical phase of the associated material, between the two aforementioned stands.

2. Rolling mill according to Claim 1, wherein the cooling device is of the hydraulic type with laminar-flow pipes (30).

3. Rolling mill according to Claim 2, wherein said pipes (30) are arranged along the travel path of the strip (N), on both sides thereof.

4. Rolling mill according to Claims 1 to 3, characterized in that it is a finishing rolling mill.

5. Rolling mill according to Claims 1 to 4, further comprising means (4) for heating the strip (N), arranged between said rolling stands (2) where the cooling device (3) is located.

6. Rolling mill according to Claim 5, wherein these heating means (4) are movable between a first operating position in which they are located between the strip (N) and a part of the pipes (30) of the cooling device (3), and a second operating position where they are at a distance from the strip.

7. Rolling mill according to Claims 5 and 6, wherein the heating means comprise a gas heater (4).

8. Rolling mill according to Claim 7, wherein the heater (4) is of the type having a direct flame acting on the strip (N).

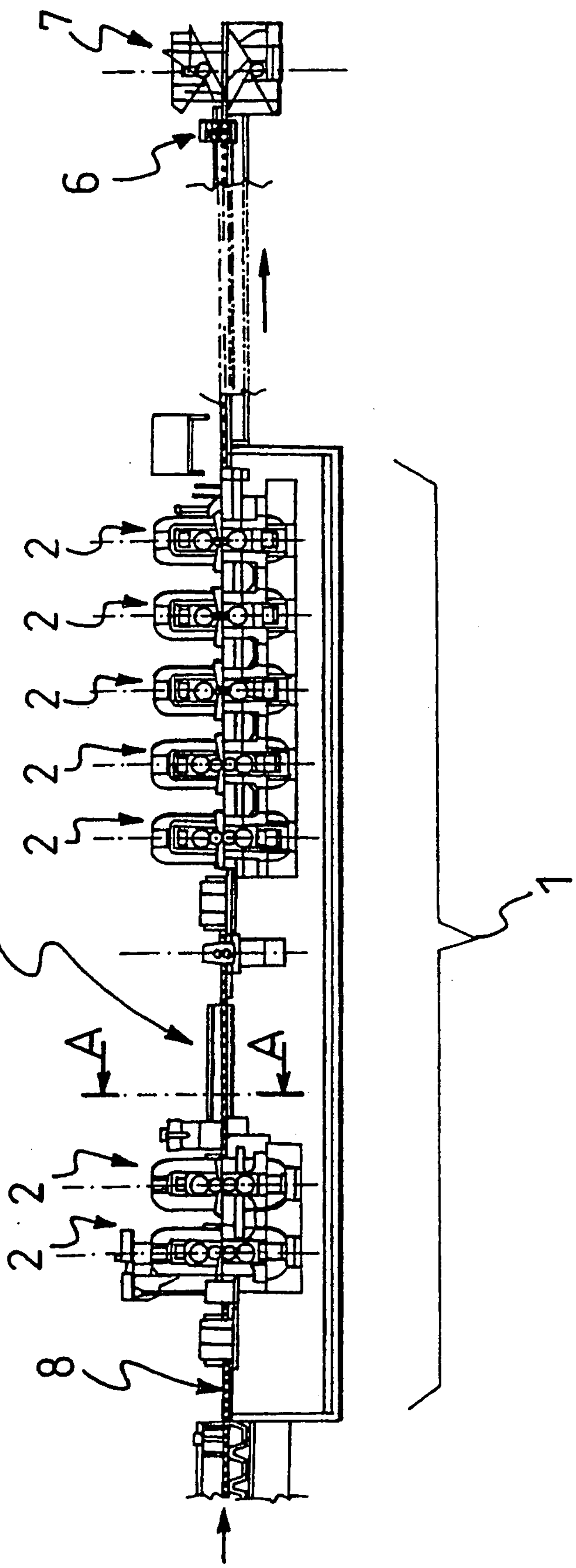

FIG.1

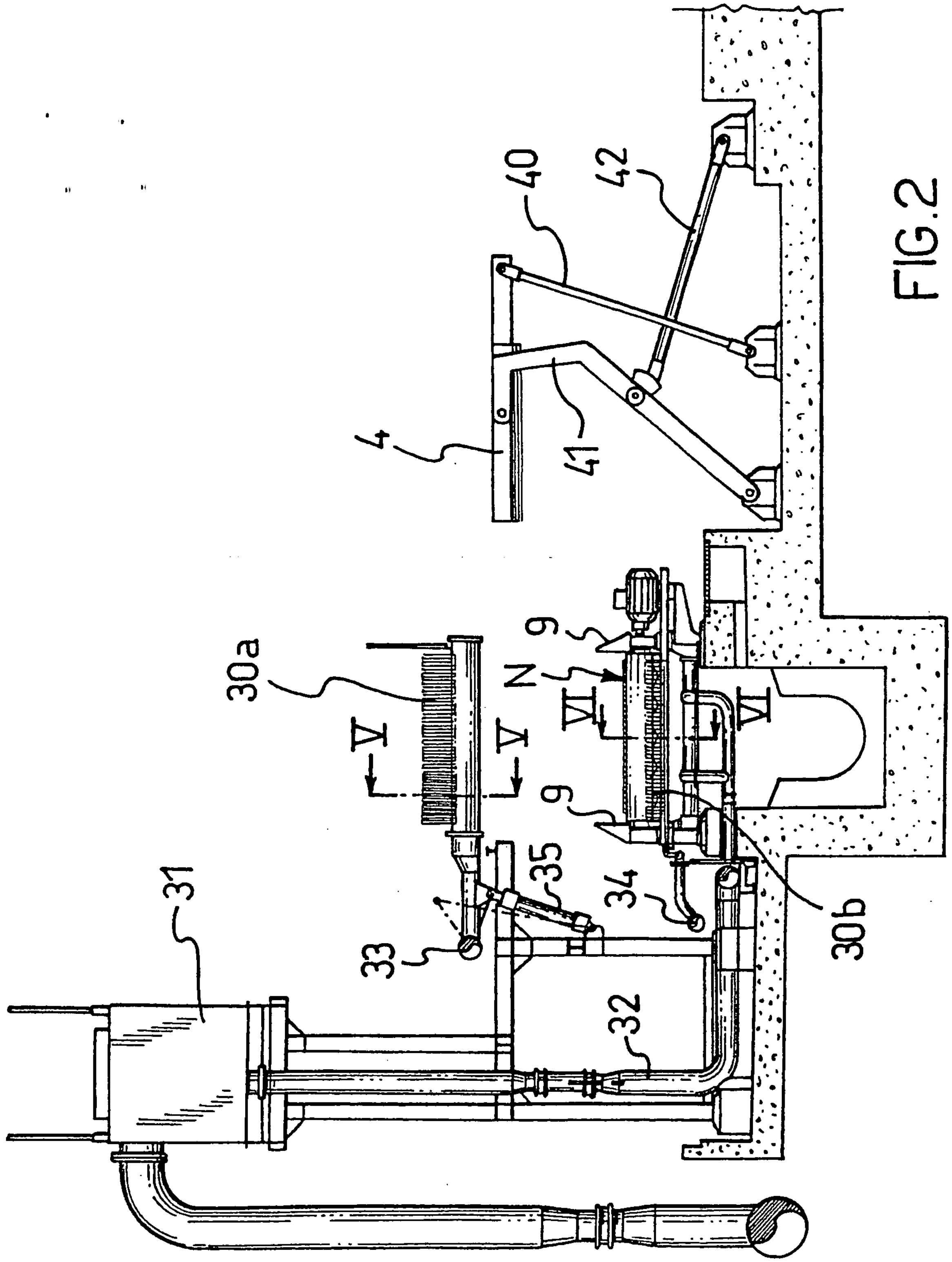

FIG.2

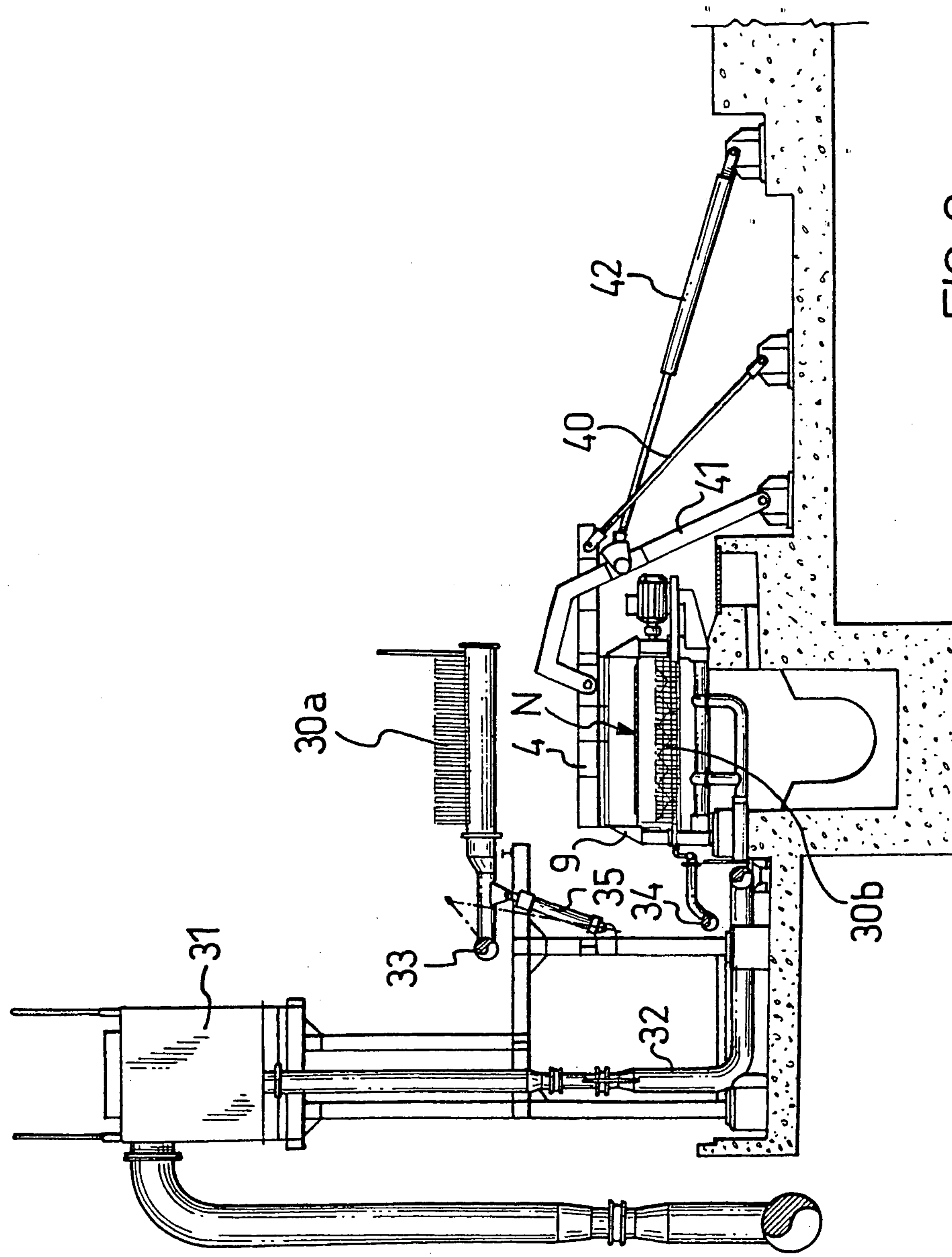

FIG. 3

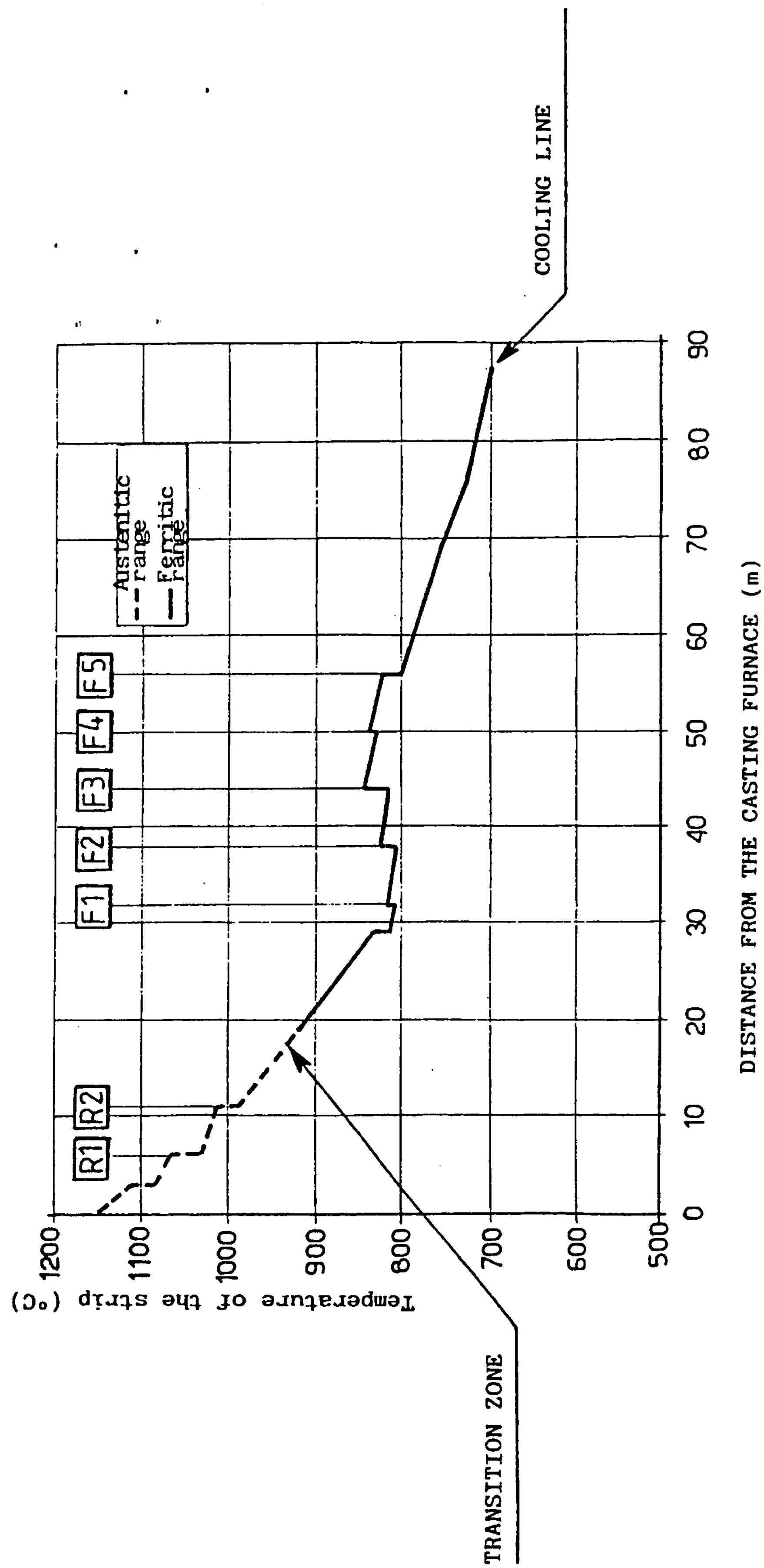
COOLING LINE
TRANSITION ZONE
Temperature of the strip (°C)
1200
1100
1000
900
800
700
600
500
0
10
20
30
40
50
60
70
80
90
DISTANCE FROM THE CASTING FURNACE (m)
R1
R2
F1
F2
F3
F4
F5
Austenitic range
Ferritic range

FIG.4

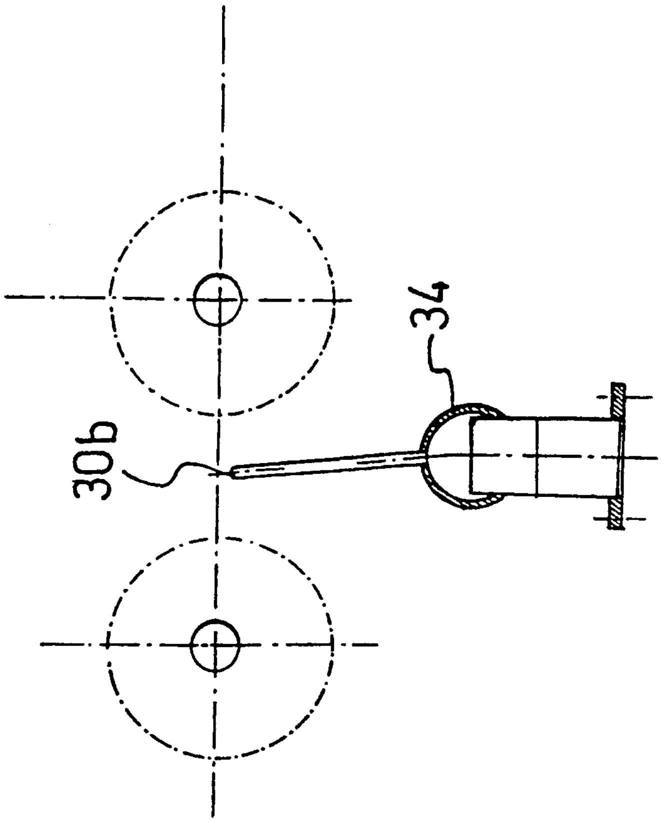

FIG.6

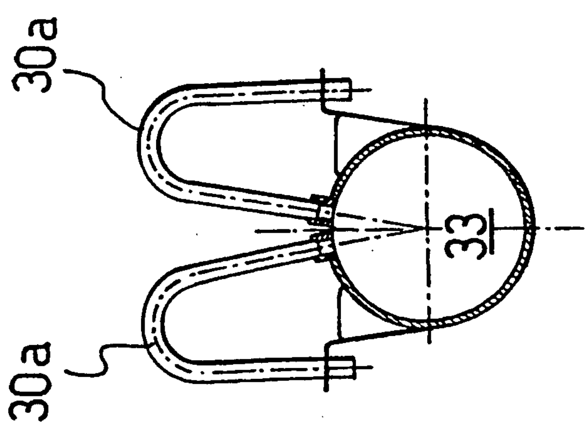

FIG.5

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B21B1/26 B21B45/02 B21B45/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 00815 A (ARVEDI GIOVANNI) 23 January 1992 (1992-01-23)	1-4
A	page 8 -page 11; claims 3-5,8; figure	5

X	EP 0 860 215 A (KVAERNER METALS CONT CASTING) 26 August 1998 (1998-08-26)	1,4,5
A	column 4 -column 10; claims 1,3-6,11; figures 1,4-7	2,3,6

X	EP 0 870 553 A (DANIELI OFF MECC) 14 October 1998 (1998-10-14)	1,4,5
A	column 6 -column 8; figures 2-4	2,3,6

P,X	WO 99 30847 A (SKODA-DOPP ULRICH ;MANNESMANN AG (DE); WEHAGE HARALD (DE); JACOBI) 24 June 1999 (1999-06-24)	1,4,5
A	page 10, line 15 -page 12, line 20; figure	2,3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 April 2000	08/05/2000

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 196 00 990 A (THYSSEN STAHL AG) 17 July 1997 (1997-07-17)	1,4
A	page 4, line 43 - line 57; figure 2	2,3,5
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 523 (M-1049), 16 November 1990 (1990-11-16) -& JP 02 220708 A (SUMITOMO METAL IND LTD), 3 September 1990 (1990-09-03) abstract	1-8
A	KOHRING FRED C: "WATERWALL water-cooling systems" IRON AND STEEL ENGINEER., vol. 62, no. 6, June 1985 (1985-06), pages 30-36, XP002135443 ASSOCIATION OF IRON AND STEEL ENGINEERS. PITTSBURGH., US ISSN: 0021-1559 page 30 -page 34; figures 1-14	2,3
T	DE 198 43 038 A (SCHLOEMANN SIEMAG AG) 23 March 2000 (2000-03-23) column 3 -column 4; claims; figures	2,3
A	DE 889 582 C (MÜNKER THEO) 10 September 1953 (1953-09-10) page 2, line 21 - line 37	7,8

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 99/09168

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9200815 A	23-01-1992	IT 1244295 B	08-07-1994
		AT 106286 T	15-06-1994
		AU 644889 B	23-12-1993
		AU 8100791 A	04-02-1992
		BG 60451 B	28-04-1995
		CA 2085223 A	10-01-1992
		DE 69102280 D	07-07-1994
		DE 69102280 T	15-09-1994
		DK 541574 T	22-08-1994
		EP 0541574 A	19-05-1993
		ES 2055608 T	16-08-1994
		FI 925907 A,B,	28-12-1992
		HU 211120 B	30-10-1995
		JP 6503853 T	28-04-1994
		NO 176949 B	20-03-1995
		RO 111166 A	30-07-1996
		RU 2070584 C	20-12-1996
		US 5329688 A	19-07-1994
		ZA 9105034 A	24-06-1992
		ZW 8091 A	18-09-1991
EP 0860215 A	26-08-1998	CA 2230013 A	21-08-1998
		CN 1195585 A	14-10-1998
		GB 2322320 A	26-08-1998
		JP 10277715 A	20-10-1998
EP 0870553 A	14-10-1998	IT 1290743 B	10-12-1998
		AU 5276898 A	15-10-1998
		CN 1195584 A	14-10-1998
		JP 10277601 A	20-10-1998
WO 9930847 A	24-06-1999	DE 19758108 C	14-01-1999
		AU 1749399 A	05-07-1999
DE 19600990 A	17-07-1997	AU 1440897 A	11-08-1997
		CA 2242728 A	24-07-1997
		WO 9726377 A	24-07-1997
		EP 0873428 A	28-10-1998
JP 02220708 A	03-09-1990	NONE	
DE 19843038 A	23-03-2000	NONE	
DE 889582 C		NONE	